TOILET TANK FILL VALVE AND METHOD OF OPERATION

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to valves and the like for controlling the flow of water into a tank, such as a toilet, and more particularly to a metered water control system for flush toilet tanks.

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Toilet Tank Fill Valve and Method of Operation

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BACKGROUND OF THE INVENTION

[0002] Toilets of the kind used in American homes, hotels and motels, are typically connected to the potable water supply. Each one uses approximately 1.5 to 4.5 gallons of water per flush. The majority of these toilets operate by means of a flotation device attached to a water flow valve. When the toilet is flushed, a chain connected to the flush handle lifts a flapper opening an outlet in the bottom of the toilet tank. The water from the tank flows into the toilet bowl raising the level of water therein. When the water in the toilet bowl exceeds the height of the bowl drain, water begins to flow from the bowl by a siphoning effect which suctions out all water and waste in the toilet bowl. During this period of time, the flotation device, floating on the water in the tank, drops as the tank water level drops. This, resultantly, opens a water inlet valve. When all water has exited the tank, the flapper falls closing the open outlet. The water now entering the tank, through the inlet valve, fills the tank. As the water level rises the float rises until the water valve is closed.

[0003] This system is effective, simple and relatively efficient. However, it can also be extremely wasteful. Should the flapper that closes the tank outlet wear, or become distorted, a leak occurs that allows water to constantly flow into the toilet bowl. If enough water escapes from the tank, the float drops opening the water inlet valve to replace the lost tank water. Conversely, the inlet valve is subject to distortion and/or the buildup of minerals, particularly in hard water areas, that interfere with its efficient operation to the point where it will never completely close. The same result may occur from improper adjustment of the flotation device. In these latter cases, there is a constant flow, however small, of water into

the tank. To preclude flooding, an overflow tube in the tank exits the excess water into the toilet bowl. Thus, the level of water in the tank never exceeds the height of the overflow tube, given the current designs, as the amount of water that may be introduced into the tank at any given time is less than the amount of water that the overflow tube permits to escape. However, this continual flow also leads to a waste of water.

[0004] In addition, most ball cock-style toilets are made from porcelain cast mold. While, such a material is cost effective and long lasting for a traditional toilet. Unfortunately, in most of these toilets, metal bolts and washers secure the secure the bowl to the upper tank and at the floor. Over time, these bolts and washers corrode and rust, resulting in weakened contact points between the upper tank and the bowl. Soon, leaks occur at these weakened contacts, causing water damage outside of the toilet. This damage extends not only sub flooring and flooring materials, but also to woodwork, sheetrock, carpeting and nearby personal property.

[0005] Still further, damage to a porcelain tanks also often occurs due to faulty repairs by plumbers or maintenance personnel, as well as by users leaning against the tank. Such damage appears as stress cracks in the porcelain tank, which cracks oftentimes cannot be readily detected by resident or users. However, a shock of cold water in a tank can cause a stress fracture or stress crack to travel quickly, resulting in a catastrophic break. These types of catastrophic events can very quickly result in heavy insurance losses and claims. For example, in less than an hour of an undetected water flow from a toilet tank can flood a large residential areas and, in an apartment or condominium home, can even affect nearby residences. Claims of this type occur daily throughout the

world, causing property insurance companies to pay annually billions in water damage claims. Today's ball cock- or float-type devices simply do not address these serious limitations.

[0006] The availability and conservation of water is a significant environmental concern. Changing weather patterns, increased agricultural needs, the cutting of woods and forests, and the increasing destruction of watersheds have reduced the quantity of fresh water available. These factors, combined with population growth, have created severe strains on the ability of both nature and man to supply the necessary potable water. It is not uncommon to hear about local water rationing during peak water use periods. The problem has become so severe in some areas that some legislatures have now enacted laws that require the use of toilets using less than the standard 3.5 gallons of water.

[0007] The toilet water conservation problem has been addressed, principally in the context of public toilets, that is, toilets in public facilities that normally do not have toilet tanks but rather have metered flush valves or other mechanical or electrical shut-off devices in the water line. However, a fluid operated valve for use with a toilet tank was disclosed in U.S. Pat. No. 1,145,791 issued to L. F. Pigott on July 6, 1915. The patent disclosed a tank inlet valve assembly comprising an impeller screw seated in an inlet housing. The impeller is connected by a shaft to a screw, intermeshing with the screw is a second screw which is connected by a rod to a valve. The valve closes an outlet port. Attached to the second screw, at the side opposite the valve is a spring that is under tension when the valve is closed. The valve is activated by pulling a flush handle. The flush handle rotates an arm that supports the rod having the valve on one end and the screw with spring assembly

on the other. This rotation disengages the two screws allowing the spring to retract, pulling the second screw, rod and valve assembly rearward to open the outlet port. When the flush handle is released, the rod is pulled back into position by a spring, remeshing the first and second screws. As the valve is opened, fluid exits through the outlet port thereby allowing water to enter through the inlet port, turning the impeller which in turn drives the first screw, now intermeshed with the second screw, until the valve is closed.

[0008] U.S. Pat. Nos. 1,552,261; 1,809,440 and 4,624,444, of Belcher, Elder and Johnson respectively, disclose metered flush valves that eliminate the need for a tank and are normally found in public facilities. The patent of Belcher, No. 1,552,261, discloses a metering device consisting of a valve that opens into the water flow and is closed by a combination of a spring pressure and water pressure. When the flush handle is turned, a mechanical linkage forces the valve open and locks it open by means of a ratchet. Water then flows through an impeller that is linked by a series of gears to a bar mechanism that is raised by the rotating impeller. The bar strikes the retaining ratchet tooth disengaging it and allowing the valve to close.

[0009] U.S. Pat. No. 1,809,440, of Elder, also discloses a valve for controlling the flow of water by turning off the water after a predetermined time or a given amount of water has passed. When the flush handle is rotated, paired inlet valves are opened to permit the water to flow. The flowing water strikes a turbine wheel. The turbine wheel is connected by a series of gears to a spiral gear that moves an arm to cause the rotation of the valves to a closed position. The patent of Johnson No. 4,624,444 is representative of shutoffs for flush toilets used in commercial establishments having pressurized lines.

[0010] Water control meters are also known for use in controlling watering devices. U.S. Pat. Nos. 4,280,530, of Yi, and 4,708,264, of Brunninga, are devices of this type. The device of Yi is placed in the water line for dispensing water to sprinklers or agricultural irrigation systems. Water enters through an inlet into an impeller chamber. The speed of rotation of the impeller is controlled by speed adjusting means which is essentially a frictional contact. The water flows from the impeller chamber into a second chamber containing the outlet valve. The outlet valve is set on one of three preset positions. Thus, the flowing water causes the impeller to rotate and an attached pinion gear initiates a gear train that terminates in a crescent gear. The crescent gear acts as a timing gear linked to the outlet valve and as it rotates, it slowly closes the valve to stop the flow of water.

[0011] Pat. No. 4,708,264, the device of Brunninga, also discloses a timed water meter for a hose or sprinkling system. The outlet valve is set to a predetermined open position and water flowing through the system rotates an impeller which is linked through a series of planetary gears to rotate the valve control assembly. The valve control assembly rotates until released, at which time it permits the valve to be closed.

[0012] An electronic water controller is disclosed in U.S. Pat. No. 4,633,905 of Wang. As water flows over a water wheel, magnetic sensors within the wheel cross a relay thereby inputting the flow rate into a microprocessor. On the basis of the flow rate and the amount of water to be dispensed, the microprocessor computes the time that the outlet valve should be open. The outlet valve is opened by rotating a cam which in turn raises a post attached to the outlet valve. The outlet valve remains open until the calculated flow time has been achieved at

which time the motor rotates the cam to a point where the post is allowed to fall and the valve closed. The valve itself is forced into a closed position by a spring.

[0013] Another device for measuring a precise amount of water is that of Johns, U.S. Pat. No. 1,407,752. This is an in line measuring device that uses a combination of gearing and pressure differential associated with a piston to control the flow of water.

[0014] U.S. Pat. No. 4,335,852, of Chow, discloses another device for controlling the flow of fluid. The device consists of a flow inlet having a valve placed therein. The valve has an associated stem that is positioned to ride on a cam. The device is pre-set for a given amount of flow. When the water flow is initiated it flows by an impeller which is connected by means of intermeshing gears to an eccentric shaft that drives a pawl and ratchet, the ratchet being attached to the cam. The ratchet rotates the cam until such time as the stem can be pushed back into the stem notch. In addition to relying on water pressure to close the valve, a spring is placed between the ferrule cup, in the inlet, and a stud in the center of the valve assembly. The sealing means is an O-ring, around the valve, that is slightly larger than the opening for the inlet valve.

[0015] In U.S. Patent No. 4,916,762 to Shaw, there is described a device for metering the flow of water into the tank and bowl of a toilet and providing a positive shut-off of the flow. When the toilet handle is turned, a linkage rotates a cam to force the stopper from its seat thereby commencing water flow. Water flows through a flow channel and past a water wheel imparting a rotation thereto. The water wheel is connected to the cam thereby rotating the cam. When the cam has rotated to position a notch over the stopper stem, the stopper is reseated by the

pressure of the water and water flow ceases. The amount of water flow permitted is a function of the number of cam notches and flow nozzle size.

SUMMARY OF THE INVENTION

[0016] The present invention provides a method and system for metering water flow into the tank of a flush toilet and automatically disabling the flow of water when a pre-determinable volume of water has flowed from an inlet tube that receives water from the water line.

[0017] According to the present invention, a metered water control system is provided to precisely control the amount of water used by a toilet, or water closet, during each flush cycle and to prevent further flow of water into the tank after the flush cycle has been completed. The invention limits the amount of water that flows into the tank per flush cycle to any pre-determinable amount, which is typically in the range of from 1.5 to 4.5 gallons.

[0018] The method of the present invention provides for water received by an inlet tube from a water source to be conducted above the water line of the tank to be channeled by a diverter to cause mechanical motion of a metering assembly comprising a control valve to enable and disable flow of water from the inlet tube. The valve is controlled by a mechanical switch responsive to the mechanical motion of the metering assembly to automatically close the inlet tube when a pre-determined volume of water has flowed through the diverter. The mechanical switch is linked through an actuator to the flush arm of the toilet, so that when the toilet is flushed the flush cycle is initiated to allow the pre-determined volume of water to be discharged into the tank.

[0019] Once the pre-determined volume of water has been discharged, the flush cycle is complete and no more water can flow into the tank, regardless of the position of the flush arm or actuator, until the toilet is flushed again. Moreover, even

if the flapper valve through which water enters the toilet bowl from the tank leaks or remains open, and even if the tank itself leaks, only the predetermined volume of water is discharged into the tank during a flush cycle.

[0020] The foregoing has outlined rather broadly aspects, features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional aspects, features and advantages of the invention will be described hereinafter. It should be appreciated by those skilled in the art that the disclosure provided herein may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. Persons of skill in the art will realize that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims, and that not all objects attainable by the present invention need be attained in each and every embodiment that falls within the scope of the appended claims.

[0021] The present invention only engages once is the event of a leak. This results only in a loss of water from the tank and 1.6 to 4.5 gallon from an engagement of the handle during a breakage event to the tank. In an optimal operation, the present invention does not engage from a breakage event, causing only loss of the water then standing in the tank. This causes the present invention to prevent catastrophic water leakage and prevents or substantially eliminates the more severe types of water damage that conventional toilet mechanisms may allow. The present invention, therefore, prohibits a continuous flow of water that may occur with a ball cock or float device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

[0023] FIGURE 1 shows assembly of the upper and lower body of a preferred embodiment of the present invention;

[0024] FIGURE 2 is a perspective view of the lower body of a preferred embodiment of the present invention;

[0025] FIGURE 3 is a perspective view of the upper body of a preferred embodiment of the present invention;

[0026] FIGURE 4 is a top perspective view of the upper body of FIGURE 3, showing the interior of an assembly housing of a preferred embodiment;

[0027] FIGURE 5 is a top perspective view of a diverter;

[0028] FIGURE 6 is a bottom perspective view of the diverter shown in FIGURE 5;

[0029] FIGURE 7 is a perspective view of a diaphragm;

[0030] FIGURE 8 is a bottom perspective view of a cone;

[0031] FIGURE 9 is a top perspective view of the cone shown in FIGURE 8;

[0032] FIGURE 10 is a top perspective view of a water wheel;

[0033] FIGURE 11 is a bottom perspective view of the water wheel shown in FIGURE 10;

[0034] FIGURE 12 is a top perspective view of a gear in a gear assembly of a preferred embodiment;

[0035] FIGURE 13 illustrates the gear assembly of a preferred embodiment;

[0036] FIGURE 14 illustrates a top gear employed in the gear assembly illustrated in FIGURE 13;

[0037] FIGURE 15 illustrates a valve assembly in a closed valve condition;

[0038] FIGURE 16 illustrates the valve assembly in the open valve condition;

[0039] FIGURE 17 is a top perspective view of a seal arm;

[0040] FIGURE 18 is a bottom perspective view of the seal arm shown in FIGURE 17;

[0041] FIGURE 19 is a perspective view of a pawl;

[0042] FIGURE 20 is a top perspective view of a control housing;

[0043] FIGURE 21 is a bottom perspective view of the control housing shown in FIGURE 20;

[0044] FIGURE 22 is a perspective view of an upper actuator;

[0045] FIGUREs 23, 24, and 25 illustrate operation of an actuator assembly; and

[0046] FIGURE 26 is a perspective view of a lower actuator.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0047] An assembly of a preferred embodiment of the present invention is shown in part in **FIGURE 1**, comprising a lower body **10** and an upper body **12**. At the uppermost portion of upper body **12** is a meter assembly housing **14**. Perspective views of lower body **10** and upper body **12** are shown in **FIGUREs 2** and **3** respectively, where like parts are like-numbered.

[0048] As can be seen, lower body **10** comprises ridges **16** that insert into a slot of a ridge cavity **18** of upper body **12**. When lower body **10** is inserted into upper body **12**, an outer shell **20** of lower body **10** fits snugly interior to an outer shell **22** of upper body **12**. Further, an inlet tube **24** of upper body **12** inserts snugly interior to an inlet tube **26** of lower body **10**. Two O-rings **35** are positioned in separate grooves on the exterior of inlet tube **24** of upper body **12** to prevent water leakage between the exterior of inlet tube **24** and the interior of inlet tube **26**.

[0049] Lower body **10** extends into upper body **12** and is fixed into place by inserting a pin into a hole **30** extending through ridge cavity **18** through a gap between ridges **16**. This enables a meter assembly within assembly housing **14** to be positioned above the water line when the tank is filled, as is sometimes required by plumbing codes.

[0050] Lower body **10** comprises a threaded end **32** that is connected to the inlet fitting on the bottom of the toilet tank in the conventional manner. The inlet fitting receives water from a water line supplied by a cold water pipe of a conventional indoor plumbing system. A gasket **34** is provided to prevent leakage and to secure the assembly of **FIGURE 1** in a vertical upright position.

[0051] Water flows into tube **26** from the water line through threaded end **32** and is conducted by pressure up through inlet tube **26** and inlet tube **24** to an upper end **36** of tube **24**. Thus, the water supply is conducted to assembly housing **14** that is positioned such that inlet tube **26** and inlet tube **24** form an inlet tube that conducts water received from the water line to a level above the water line of the tank.

[0052] **FIGURE 3** also shows an overflow outlet **38**, control housing retaining slot **40** and actuator housing **42**. Overflow outlet **38** simply allows for overflow to be conducted to an overflow tube in the event of overflow as required by plumbing codes. Control housing retaining slot **40** and actuator housing **42** will both be discussed below in conjunction with the assembly and operation of a preferred embodiment of the invention.

[0053] Shown in **FIGURE 4** is a top-perspective view of upper body **12**, showing the interior of assembly housing **14**. A water diversion fixture **44** can be seen at the upper end **36** of inlet tube **24**, which is preferably integrally molded to diversion fixture **44**. Water diversion fixture **44** is attached and mounted to the interior wall of outer shell **22** by mounts **46** which are uniformly positioned around the circumference of the interior wall of outer shell **22**.

[0054] The outer diameter of diversion fixture **44** is sufficiently less than the interior diameter of outer shell **22** to enable water that passes upward and out of upper end **36** of inlet tube **24** to freely flow downward there between and exit from the lower end of lower body **12** through outlet holes **47** distributed about the periphery of outer shell **20**. Thus, exterior shells **20** and **22** form a discharge tube that discharges water received from the diverter into the tank.

[0055] Removably insertable into diversion fixture **44** is a diverter **48** as shown in top perspective view in **FIGURE 5**. Fins **50** of diverter **48** snugly insert in gaps **52** between grooved ridges **54** of diversion fixture **44**. A bottom perspective view of diverter **48** is shown in **FIGURE 6**. In an open-valve condition, as will be described in detail below, channels **56** will channel water rising up from inlet tube **24**, so that water flows along vertical walls **58** of each fin **50**.

[0056] Removably insertable above diverter **48** is a thin diaphragm **60**, which has a small hole **62** in its center, as shown in **FIGURE 7**. Diaphragm **60** will, in a closed-valve condition, seal off end **36** of tube **24** and prevent water from flowing through channels **56**.

[0057] Removably insertable above diaphragm **60** is a cone **66**, shown in **FIGURE 8**, with ridges **68** that cooperatively mate with grooved ridges **54** of diverter **48**. In the center of the concave bottom surface **70** of cone **66** is a small hole **72** that conducts water upward through an upward-extending tube **74** of cone **66** when in an open valve condition. A top perspective view of cone **66** is shown in **FIGURE 9**. As can be seen, a hole **76** in the top of tube **74** allows water to flow out of tube **74** when in an open-valve condition.

[0058] Shown in **FIGURE 10** is a top perspective view of a water wheel **78**. Wheel **78** is removably insertable over cone **66** so that the upward-extending portion of tube **74** of cone **66** extends through a center hole **80** of wheel **78**. Shown in **FIGURE 11** is a bottom perspective view of water wheel **78**. As can be seen, wheel **78** comprises interior fins **87**. In an open valve condition, water flowing through channels **56**, as channeled by vertical walls **58** of fins **50**, will strike fins **87** of wheel **78** at about a 30-degree angle. This causes water wheel **78** to rotate about an axis

passing through the axial center of tube **74** of cone **66**. This in turn causes concentric rotation of the small gear **82** integrally formed on the upper surface of wheel **78**. Thus, diverter **48** channels the flow of water received from the inlet tube formed by inlet tubes **24** and **26** to cause mechanical motion responsive to the channeled flow.

[0059] The upper surface **84** of wheel **78** is approximately flush with a horizontal surface **86** of assembly housing **14** shown in **FIGURE 4**. Removably insertable onto a gear post **88** is a gear **89**, shown in perspective view in **FIGURE 12**, such that gear post **88** extends through a center hole **90** of gear **89**, and such that teeth **92** of gear **89** mesh with the teeth of small gear **82** on the upper surface of wheel **78**. Thus, when water causes rotation of small gear **82** of wheel **78**, rotation of gear **89** about a vertical axis passing through the axial center of gear post **88** will occur.

[0060] Shown in **FIGURE 13** is a simplified illustration of the gear assembly of the present invention for metering the flow of water into a toilet. As described above, water wheel **78** inserts onto tube **74** of cone **66** (not shown in **FIGURE 13**) and gear **89** inserts onto gear post **88** so that its teeth mesh with small gear **82** of wheel **78**. Integrally molded onto gear **89** is a small gear **92** that rotates concentrically with gear **89**.

[0061] Inserted onto the upward extending portion of tube **74** of cone **66** is another gear **94**, essentially identical in size and form to gear **89**, such that tube **74** extends through a center hole in gear **94**, and such that the outer teeth of gear **94** mesh with the small inner gear **92** of gear **89**. Thus, when water causes rotation of gear **89**, rotation of gear **94** about a vertical axis passing through the axial center of tube **74** will occur. Integrally molded onto gear **94** is a small inner gear **96** that rotates concentrically with gear **94**.

[0062] Another gear **98**, essentially identical in size and form to gears **89** and **94**, inserts onto gear post **88** such that its outer teeth mesh with inner gear **96** of gear **94**. Thus, gear **98** is caused by the rotation of gear **96** to rotate about the vertical axis passing through the axial center of gear post **88**. Integrally molded onto gear **98** is a small inner gear **100** that rotates concentrically with gear **98**.

[0063] Finally, a top gear **102**, shown separately in **FIGURE 14**, inserts onto tube **74** such that its outer teeth **106** mesh with the teeth of small inner gear **100**. Thus, top gear **102** is caused by the rotation of gear **100** to rotate about the vertical axis passing through the axial center of tube **74**. Note that top gear **102** further comprises a cylindrical protrusion **110**. When the gear assembly of the present invention is assembled, tube **74** of cone **66** extends slightly above protrusion **110** so that a seal arm, to be discussed below, can seal and prevent water flow out of the top end **74** of cone **66** in a closed valve condition. Also note that top gear **102** comprises a set of semi-circular vertical ridges **112** integrally molded onto top gear **102** and separated by gaps **114**. As will be explained in more detail below, semi-circular ridges **112** form a portion of a control mechanism for sealing and unsealing tube **74**.

[0064] In a closed valve position no water flows out of the top end **36** of inner tube **24** and, consequently, wheel **78** is not caused to rotate. In an open valve condition, water flows from the top end **36** of inner tube **24** and is channeled by diverter **48** into a set of equally spaced streams around the periphery of diverter **48**, thereby striking fins **87** of water wheel **78** and causing wheel **78** to rotate. Rotation of wheel **78** causes rotation of top gear **102** by way of the intermediate gears lying there between.

[0065] **FIGUREs 15** and **16** functionally illustrate the operation of the valve assembly of the present invention. In the closed position shown in **FIGURE 15**, a seal arm **116** under which an elastomer **118** is fitted is forced downward by a spring (not shown) to cause the elastomer **118** to seal the hole **76** at the top end of tube **74**, which extends through hole **105** slightly above the cylindrical protrusion portion **110** of top gear **102**.

[0066] A top perspective view and bottom perspective view of seal arm **116** are shown in **FIGUREs 17** and **18**, respectively. A right-angle protrusion **122** extending downward from seal arm **116** forms a mechanism into which the flat flexible rectangular elastomer **118** (not shown in **FIGUREs 17 and 18**) is inserted. The thickness of elastomer **118** is such that it can be compressibly and removeably inserted laterally into the notch **120** formed by right-angle protrusion **122**.

[0067] Returning to **FIGURE 15**, in a closed valve position where the seal arm **116** seals off the end of tube **74**, an upward water pressure P1 is counteracted by a downward pressure P2 that is differentially greater than P1, so that diaphragm **60** is held against the upper end **36** of tube **24**. In this closed valve condition, no water flows out of tube **24** and wheel **78** is not caused to rotate.

[0068] In **FIGURE 16** the open valve condition is shown. The seal arm is lifted allowing water to flow from hole **76** of tube **74** of cone **66**. This allows diaphragm **60** to be forced upward toward concave lower surface of **70** of cone **66**, and also enables water to flow upward through hole **62** of diaphragm **60**. When diaphragm **60** is forced upward by pressure of water in tube **24**, water is able to flow out of end **36** of tube **24** against diaphragm **60**, which directs the water downward through diverter **48** (not shown

in **FIGUREs 15** and **16**) generally in the direction of the arrows shown in **FIGURE 16**.

[0069] More specifically, in the open valve condition, water flows laterally through channels **56** of diverter **48** and strikes fins **87** of water wheel **78**, thereby causing wheel **78** to rotate. The water released from tube **24** then flows downward and enters into the tank through holes **47** uniformly space around the circumference of lower body **10**. This allows water to flow into the tank in the open valve condition. Thus, cone **66** and diaphragm **60** act as a control valve that enables water to flow from the inlet tube to the diverter when the valve is open and that disables water from flowing from the inlet tube when the valve is closed.

[0070] The lifting and lowering of seal arm **116**, and consequently, the establishment of an open-valve or closed-valve position, is controlled by the position of a pawl **124**. Pawl **124** is shown separately in **FIGURE 19**. When positioned within a control housing, to be discussed below, pawl **124** pivots about a notch point **126** so that end **128** of pawl **124** may be placed in a downward or upward position.

[0071] When end **128** of pawl **124** is in the downward position, as depicted in **FIGURE 15**, seal arm **116** is forced downward by a spring (not shown) to seal hole **76** of tube **74** of cone **66**. When end **128** of pawl **124** is in the upward position, as depicted in **FIGURE 16**, seal arm **116** is lifted upward by edge **130** of pawl **124**, which forces upward against edge **123** of seal arm **116**, to unseal hole **76** of tube **74** of cone **66**.

[0072] Shown in **FIGUREs 20** and **21** are a top perspective view and bottom perspective view, respectively, of a control housing **132** for housing seal arm **116** and pawl **124**. At one end of control housing **132** is a protruding ridge structure **134** that cooperatively mates with the slot structure **40** (shown in **FIGUREs**

3 and 4) formed in upper assembly housing **14**. End **128** of pawl **124** removeably inserts between ridges **136** and **138** such that when placed in position therein edge **130** of pawl **124** faces upward, and notch **126** of pawl **124** rests on an edge **140** of control housing **132**. When so positioned, pawl **124** is able to pivot about notch **126** to enable end **128** to move upward and downward to raise and lower seal arm **116**.

[0073] Note that pawl **124** exhibits an upper protrusion **133** such that when pawl **124** is properly positioned within control housing **132** interference between upper protrusion **133** and the upper interior surface of control housing **132** prevents pawl **124** from being inadvertently pulled laterally out of housing **132** when housing **132** is positioned in slot **40**.

[0074] The end **142** of pawl **124**, opposite end **128**, extends outward between ridges **136** and **136** of control housing **132**, and consequently extends outward from assembly housing **14**, such that a notch **144** in pawl **124** is exposed and enables attachment of a chain thereto. When that chain is pulled downward, thereby pulling down end **142** of pawl **124**, pawl **124** pivots about notch point **126**, thereby lifting end **128** of pawl **124**.

[0075] Seal arm **116**, and elastomer **118** affixed thereto, is also inserted into control housing **132**, and is positioned such that an edge **146** of seal arm **116** rests upon an edge **148** of control housing **132**, and such that a spring (not shown) is removably fixed at one end to cylindrical protrusion **150** extending upward from seal arm **116** and removably fixed at an opposite end to cylindrical protrusion **152** on the upper interior surface of control housing **132**. Thus, seal arm **116** is positioned within control housing **132** above pawl **124** such that spring tension exerts a downward force on seal arm **116**.

[0076] The assembly of the spring, pawl arm, seal arm and control housing is positioned with ridge structure **154** inserted into slot **40** such that a pair of curved semi-circular ridges **156** of control housing **132** insert interior to semi-circular ridges **112** of top gear **102**. When the assembled control housing is so positioned, seal arm **116** and elastomer **118** are positioned above tube **74** of cone **66** and such that end **128** of pawl **124** lies in a gap **114** between semi-circular ridges **112**. Unless and until end **142** of pawl **124** is pulled downward, thereby causing end **128** of pawl **124** to be pulled upward, end **128** will be held in the gap **114** by seal arm **116**. This is the closed valve condition wherein water wheel **78** cannot turn and water cannot flow from tube **24**.

[0077] However, when end **142** of pawl **124** is pulled downward, end **128** of pawl **124** lifts upward against spring tension to lift seal arm **116**, placing the device in an open valve condition, thereby starting the flush cycle. Bottom surface **131** of pawl **124** is lifted above the top surface **115** of a semi-circular ridge **112** of top gear **102**. This enables top gear **102** to turn in mechanical response to the rotation of wheel **78** caused by flow of water through diverter **48**. As top gear **102** rotates, surface **131** rides atop surface **115** of a ridge **112** until the next gap **114** is reached, at which time, end **128** of pawl **124** drops into the gap. When pawl **124** drops into the gap, rotation of top gear **102** is forced to stop and simultaneously, seal arm **116** is forced by spring pressure downward to seal tube **74**. This in turn causes diaphragm **60** to be forced downward, thereby sealing off tube **24**. When tube **24** is again sealed off, no more water flows into the tank and the flush cycle is completed.

[0078] Thus, semi-circular ridges **112** with gaps **114** forms a cam that moves in response to the mechanical motion of the wheel and gear assembly caused by the flow of water from the diverter. The

pawl acts as a cam engager that causes the control valve formed by the diaphragm and cone to close in response to a pre-determinable extent of motion of the cam. Combined, the cam and pawl implement a mechanical switch, responsive to the motion caused by the flow of water from the diverter that closes the control valve when a pre-determinable volume of water flows from the inlet tube.

[0079] The upper assembly housing **14** may be covered with a cover that removeably snaps into place to protect the meter assembly described above from contaminates. If maintenance or inspection of the meter assembly is desired, the cover can be removed, and some or all of the parts inserted within assembly housing **14** can be easily and quickly removed and reassembled or replaced.

[0080] As noted above, the end **142** of pawl **124** extends outward from assembly housing **14**, such that notch **144** is exposed and enables attachment of a chain thereto. That chain hangs downward and an opposite end of the chain is attached to an actuator mechanism as will now be described. Shown in **FIGURE 22** is a perspective view of an upper actuator **158**. The chain connected at one end to notch **144** of pawl **124** is connected at the opposite end to a notch **160** of upper actuator **158**. When so connected, a downward motion of notch **160** will pull the chain downward, thereby pulling downward end **142** of pawl **124**, which in turn lifts end **128** of pawl **124** out of a gap **114**, in order to begin a metered flush cycle.

[0081] An illustration of the operation of the actuator mechanism of the present invention is shown in **FIGUREs 23, 24** and **25**. In **FIGURE 23** upper actuator **158** is shown in its quiescent position within actuator housing **42**. Attached to upper actuator **158** is lower actuator **162** shown in perspective view in **FIGURE 26**. Upper and lower actuators **158** and **162** are connected to each

other by a pin (not shown) inserted through holes **163** of lower actuator **162** and a hole **159** in upper actuator **158**. Lower actuator **162** exhibits flared wings **164** that prevent the assembled actuator mechanism from being pulled out and away from actuator housing **42**.

[0082] **FIGURE 23** shows a chain **168** in a slack condition with one end connected to a notch **166** of upper actuator **158**. Chain **168** rises upward and is connected at the other end to the conventional flush arm (not shown) of a toilet. Connected to notch **160** is a second chain **168** that is connected at its other end to notch **144** of pawl **124**, which extends out of assembly housing **14** approximately directly above notch **160**.

[0083] Referring to **FIGURE 24**, when the toilet is flushed, the flush arm is raised at the far end to which chain **168** is connected. This lifts the flapper which is connected to the flush arm typically by a chain, thereby allowing water to flow from the tank into the bowl of the toilet. Raising the flush arm also simultaneously pulls the slack from chain **168** exerting an upward force on upper actuator **158** at notch **166**. In response, upper actuator **158** pivots about notch **170**, such that notch **160** is forced downward. This causes chain **168** to exert a downward force on end **142** of pawl **124**. This starts the metered flush cycle as described above. When the flush arm is released and returns to its quiescent position, chain **168** becomes slack, and upper actuator **158** returns to its quiescent position, as shown in **FIGURE 23**.

[0084] In the event the flush arm pulls up to far, upper actuator may be pulled out of actuator housing **42** as shown in **FIGURE 25**. In this event interference of wings **164** of lower actuator **162** with the upper edges of actuator housing **42** prevents the actuator mechanism from being removed from actuator housing **42**.

Therefore, the actuator is restrained by the actuator housing to be retained partially therein. The action of the actuator also ensures that chain **168** will be slack to allow end **142** of **124** to pivot back upward. When the flush arm is released, the actuator mechanism then returns to its quiescent state as shown in **FIGURE 23**.

[0085] Thus the actuator is linked to the flush arm and to the mechanical switch formed by the pawl and cam to open the control valve formed by the cone and diaphragm in response to motion of the flush arm to allow a pre-determinable volume of water to discharge into the tank. Note that once the toilet is flushed causing the actuator assembly to exert downward force on end **142** of pawl **124**, the metered flush cycle assembly in assembly housing **14** operates independently of the position of the actuator and flush arm and independently of the position of the flapper.

[0086] Thus, for example if the flapper leaks or does not close, the tank will not fill, but water will nevertheless cease to flow into the tank once the flush cycle assembly completes its operation. That is, once end **128** of pawl **124** falls back into a gap **114** between semi-circular ridges **112**, the flush cycle ends and no more water will flow from tube **24** into the tank (or into the overflow tube), regardless of the position of the flapper, the actuator or the flush arm.

[0087] Note also that the pre-determinable volume of water that flows out from holes **47** into the tank during the metered flush cycle of the present invention is independent of the water pressure received from the water line. Higher pressure merely causes the flush cycle to complete more rapidly, as higher pressure causes water wheel **78** to rotate with higher angular velocity, thereby causing more rapid rotation of top gear **102**.

Nevertheless, the cycle still terminates when the pawl end drops into the gap, as described above.

[0088] The duration of the flush cycle is desirably limited to about a minute or less. This can be controlled by the gearing ratio in the gearing assembly as would be recognized by one of ordinary skill in the art. Also, the pre-determinable volume of water that flows into the tank during a flush cycle can also be controlled by adjusting the position and number of gaps **114** and semi-circular ridges **112** in top gear **102**. This enables the invention to easily be adapted to tanks of different volumetric capacities. Also, as mentioned above, tanks of different heights can be accommodated by adjusting the height of the assembly as described in conjunction with **FIGURE 1**.

[0089] The present invention can be implemented by using low-cost lightweight components made of PVC or other materials now known in the art or to be developed. Because the invention automatically disables the flow of additional water from the water line once a pre-determined volume of water has flown there from, water will not continue to flow and be wasted or leaked because of, for example, a leaking flapper, cracked toilet tank or other defect. Also, a preferred embodiment of the invention provides a much less noisy flush since the metering assembly and inlet tube are interior to and insulated by the shell of the upper body. Further, because the height of the inlet tube and metering assembly can be adjusted to ensure that water in the inlet tube is conducted to a level above the water line of the tank, the present invention conforms to the Universal Plumbing Code and other standards for the prevention of siphoning.

[0090] Thus, although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made

herein without departing from the spirit and scope of the invention as defined by the appended claims. The invention achieves multiple objectives and because the invention can be used in different applications for different purposes, not every embodiment falling within the scope of the attached claims will achieve every objective.

[0091] Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.